CMOS LTE Transmitter Front-End

Master Thesis Defense

Presented by

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Outline

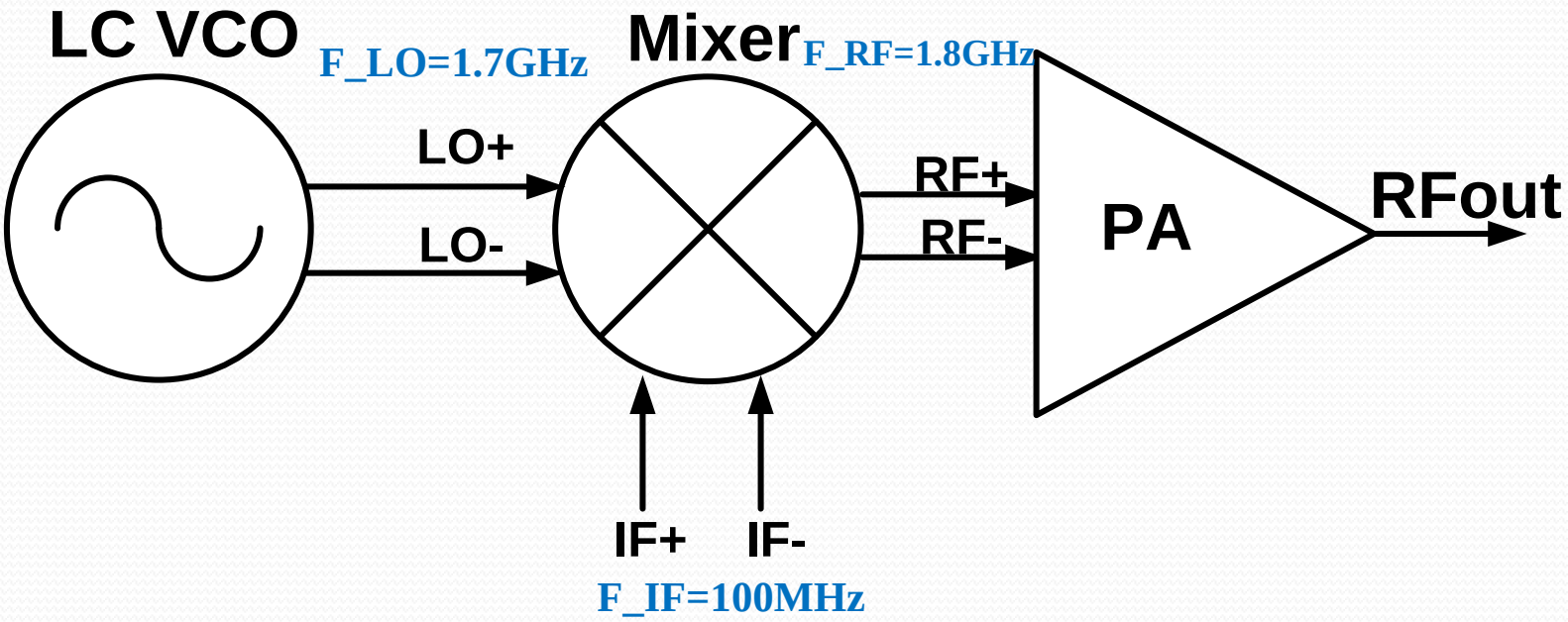
- **Introduction.**
- **CMOS LTE Transmitter Front-End.**
- **LC voltage controlled oscillator.**
- **Up-conversion mixer.**
- **Power Amplifier with pre-distortion linearizer .**
- **Transmitter Performance.**
- **Conclusions and future work.**

Introduction

- Long Term Evolution (LTE) is commonly identified as the fourth generation 4G/5G communication systems.
- LTE operates over the frequency band from 400MHz to 4GHz.
- It mainly targets high user data rates up to 75 Mbit/s for uplink and up to 300Mbit/s for downlink.
- Bandwidth from 1.4MHz to 20MHz for each channel.

CMOS LTE Transmitter Front-End

- LTE Transmitter operates at frequency range 1710-1785GHz (Uplink) and 1805-1880GHz (Downlink).



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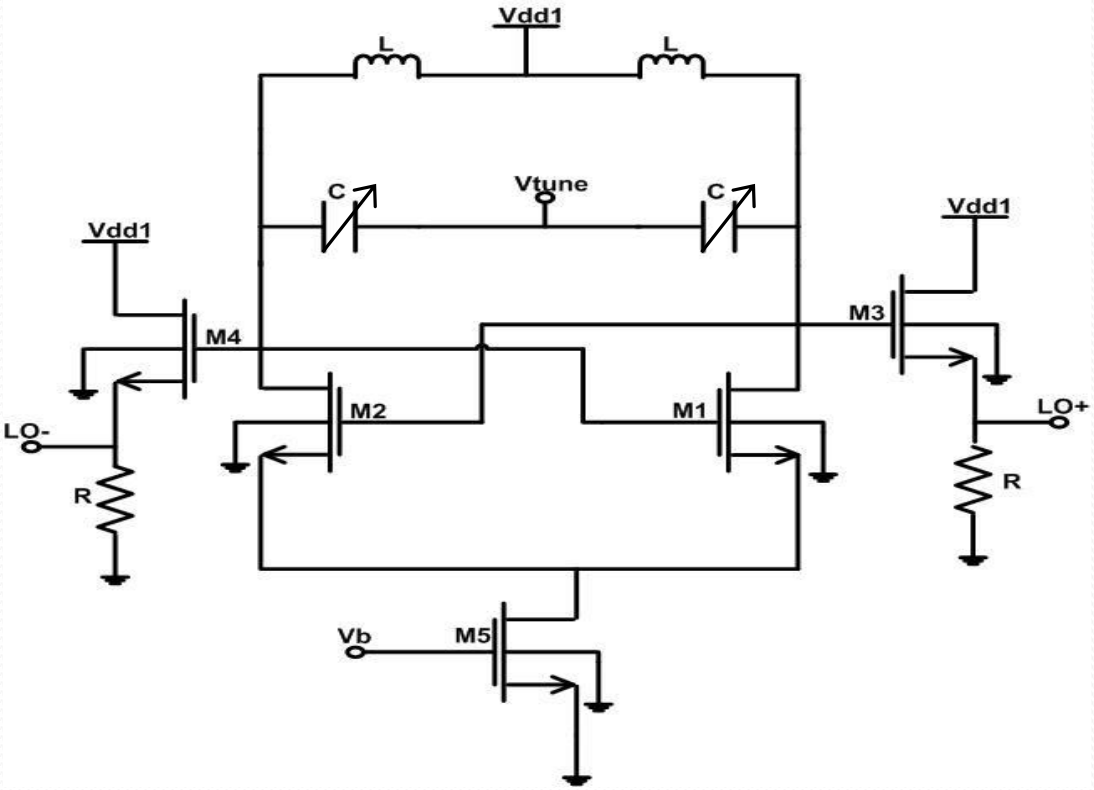
LC Voltage Controlled Oscillator

Design Parameters

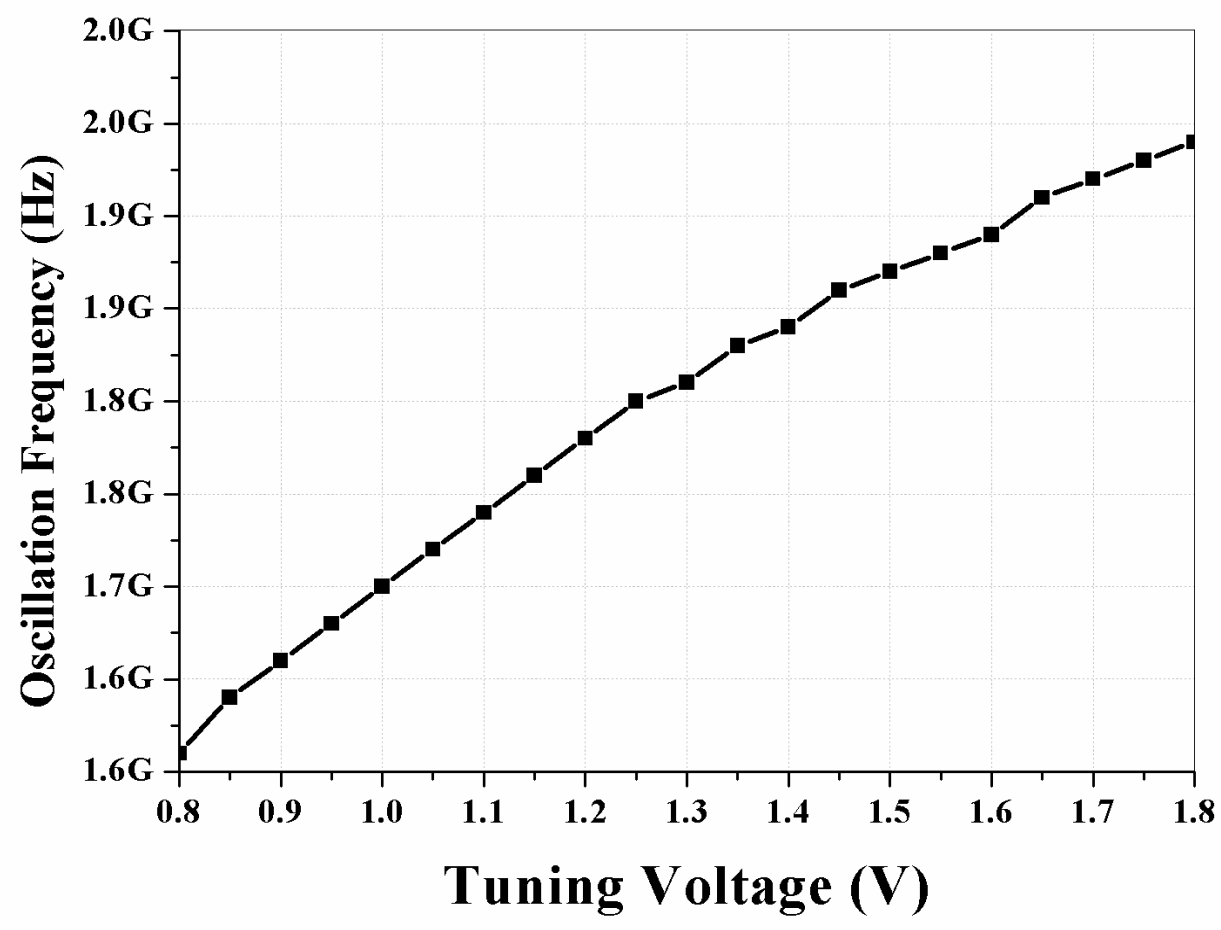
- **The oscillation frequency versus the tuning voltage**
- **Power consumption**
- **Phase noise**

LC voltage controlled oscillator

- LC VCO is designed at 1.7GHz and covers a wide range of frequency from 1.6GHz to 1.9GHz.

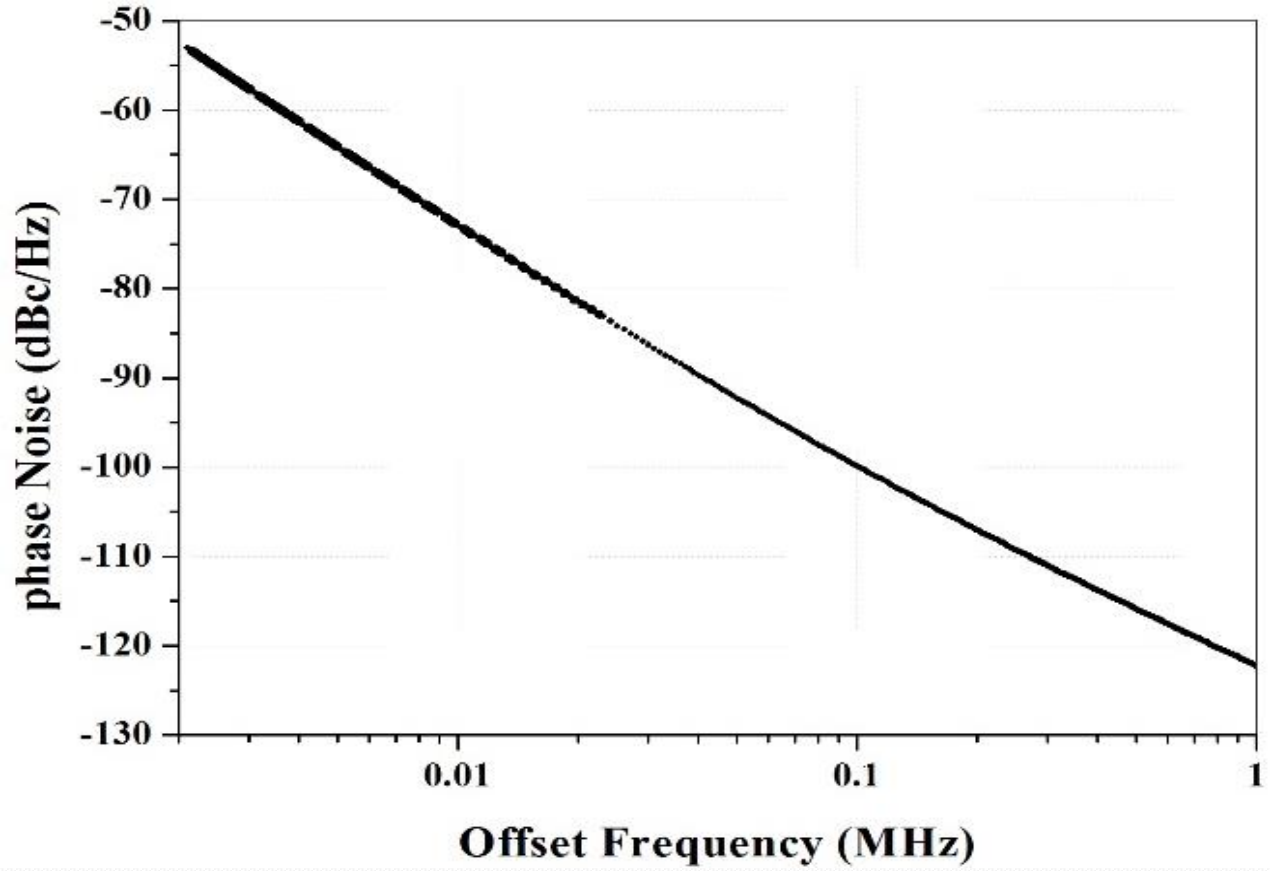


Oscillation Frequency



Phase Noise

- -121.1dBc/Hz at 1MHz offset frequency from 1.7GHz carrier.
- The VCO dissipates 19mW from a 1.2V supply.



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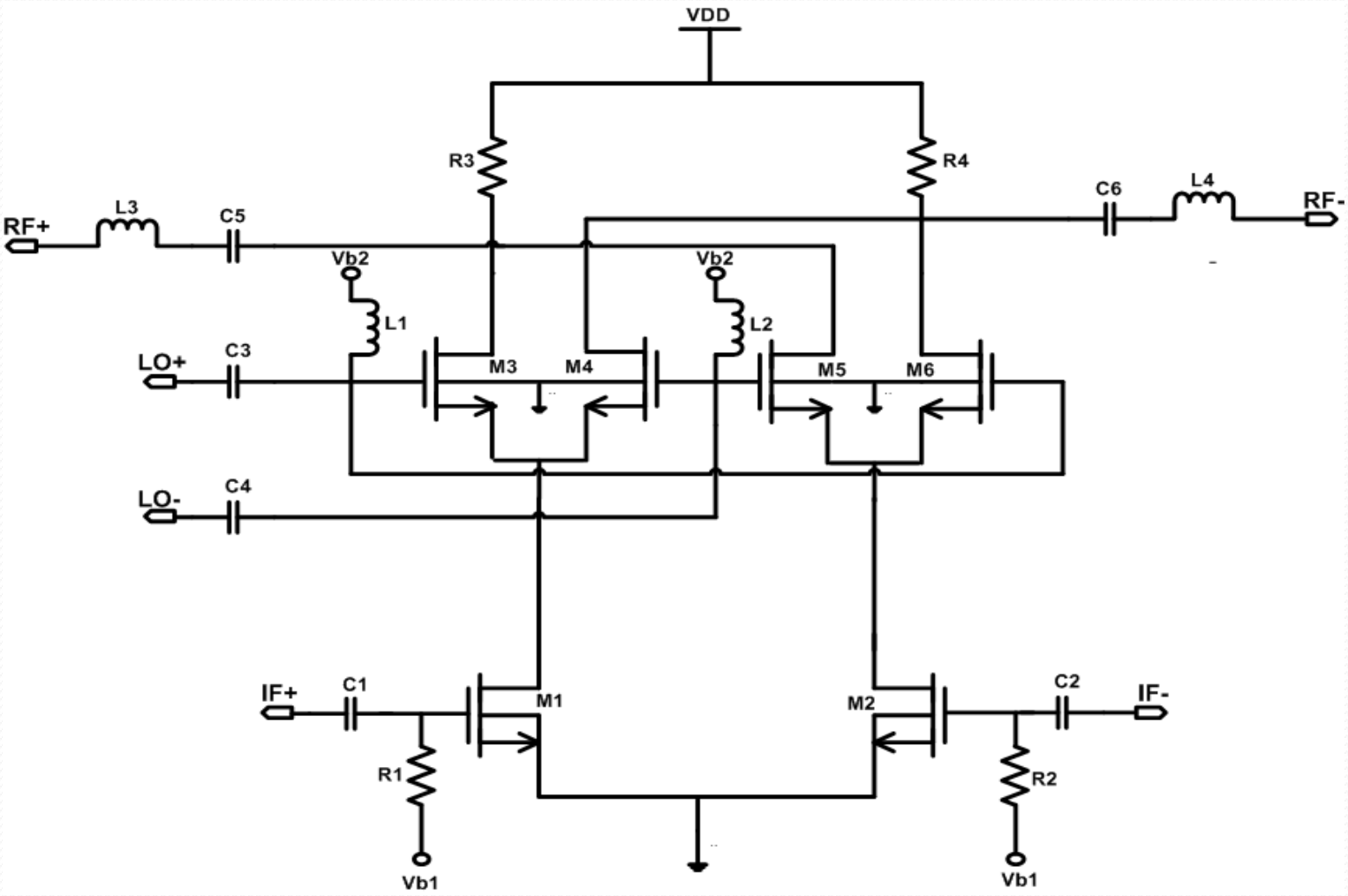
Up-conversion Mixer

Design Parameters

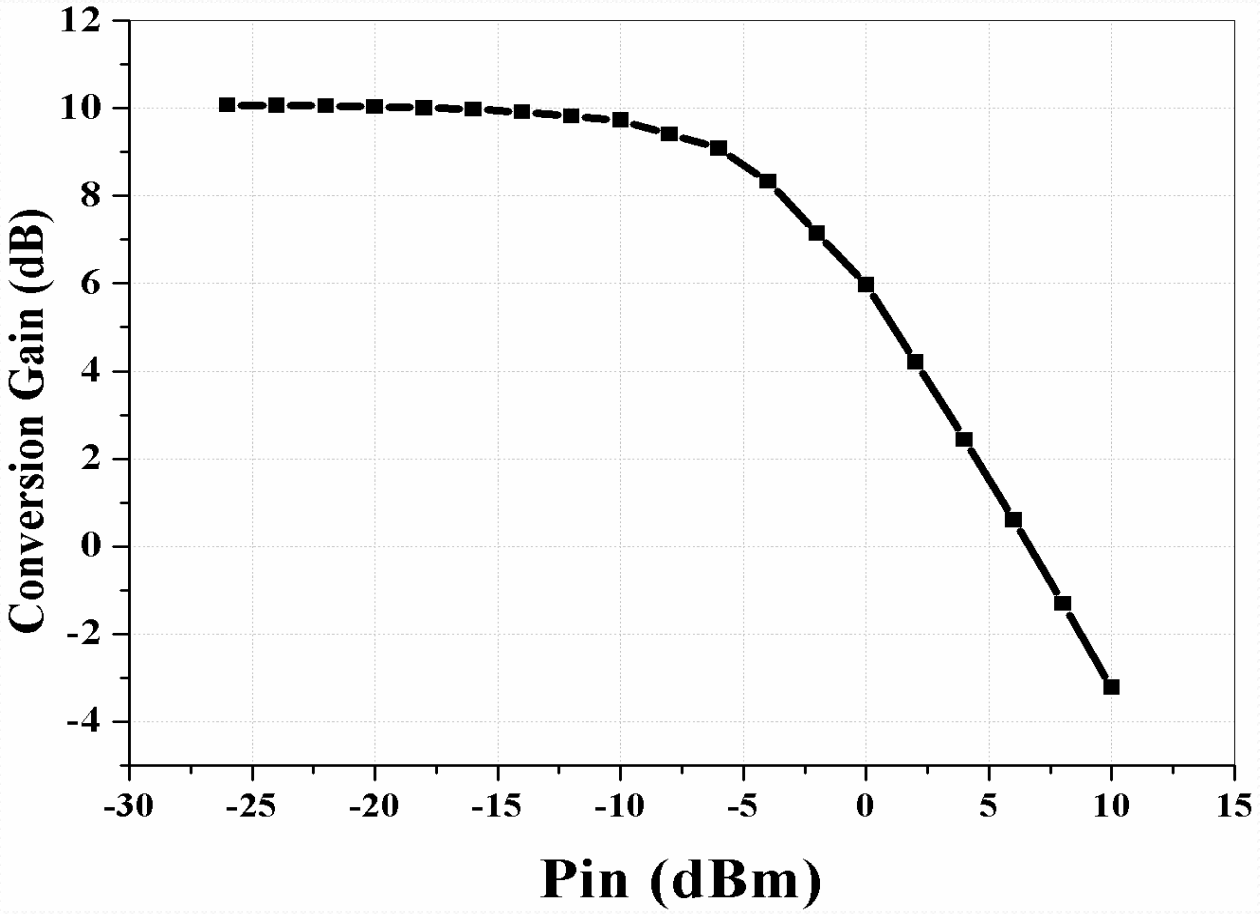
- Conversion Gain
- Output Power
- Power consumption
- Noise Figure

Up-conversion mixer



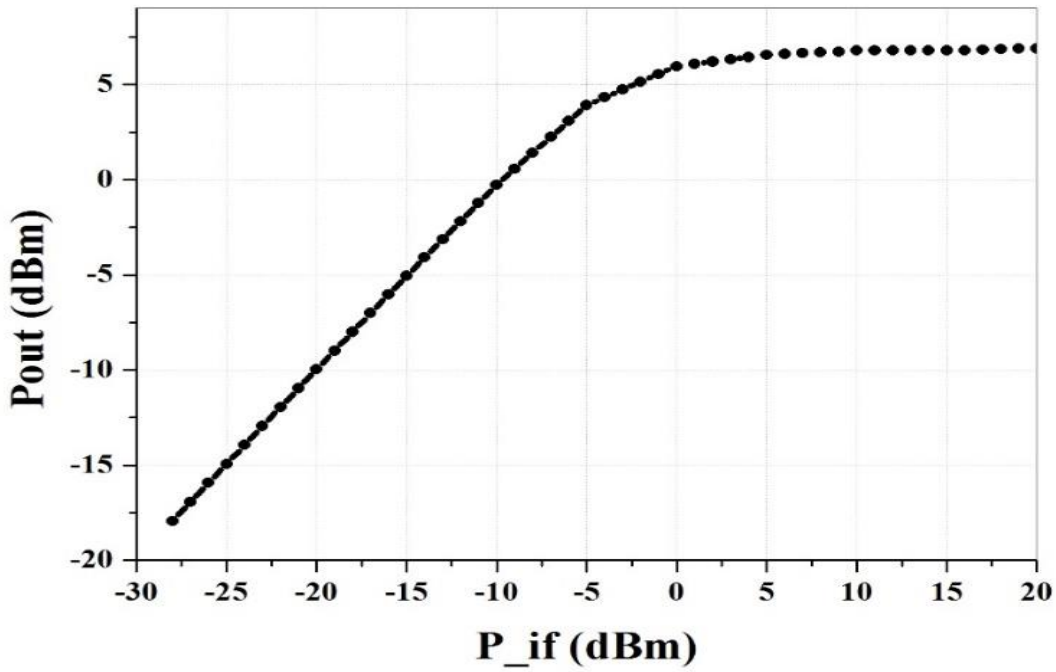
Conversion Gain

- The proposed mixer provide conversion gain of 10dB.



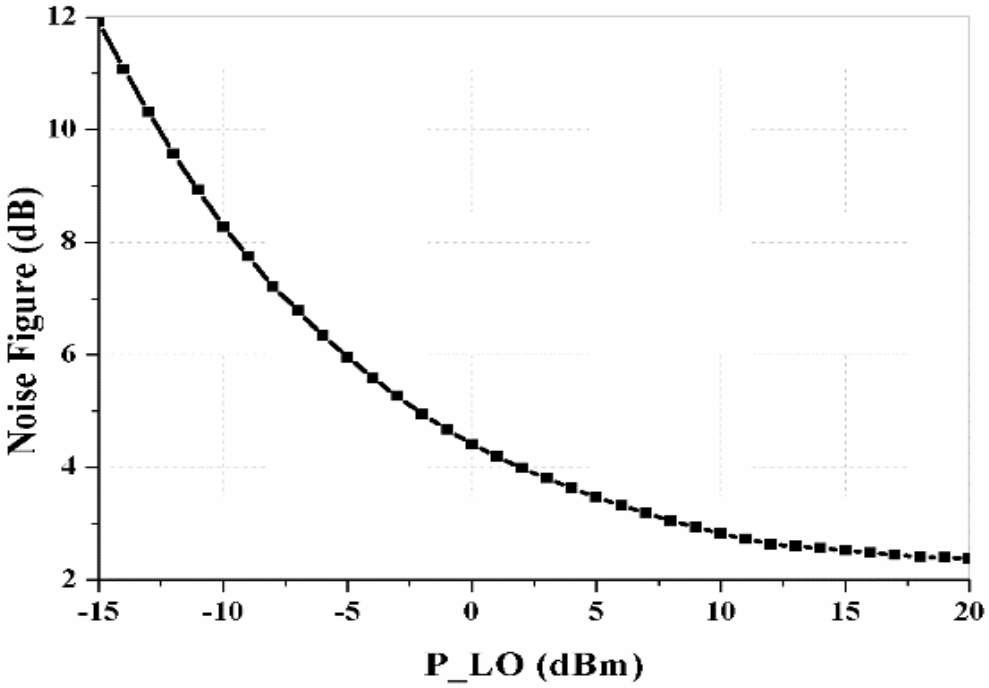
Output power

- The output power (P_RF) of the proposed mixer.
- An output P1dB gain compression point of 3.1dBm.
- Input P1dB gain compression point of -6dBm.



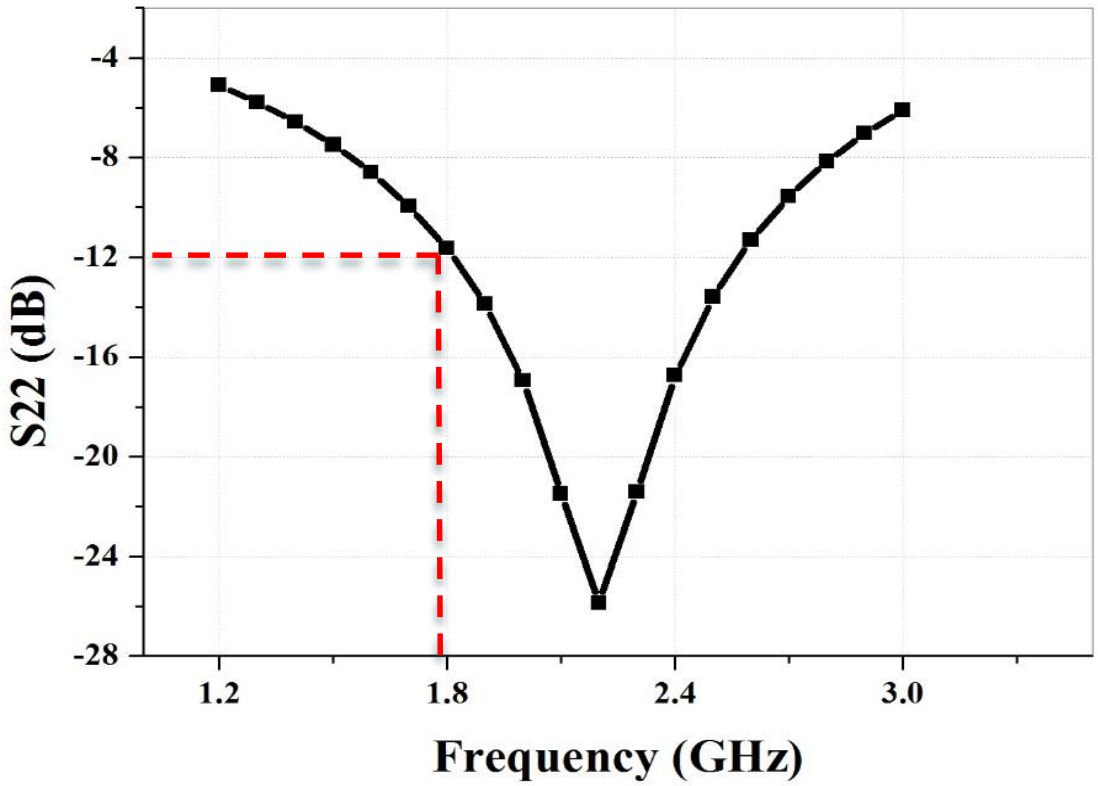
Noise Figure

- This mixer provides DSB NF of 3dB at P_LO is 5dBm.
- Supply voltage of 3.3V, and power consumption of 47mW.



Output return loss

- The output return loss of Up converted mixer, S22 is -12dB at 1.8GHz.



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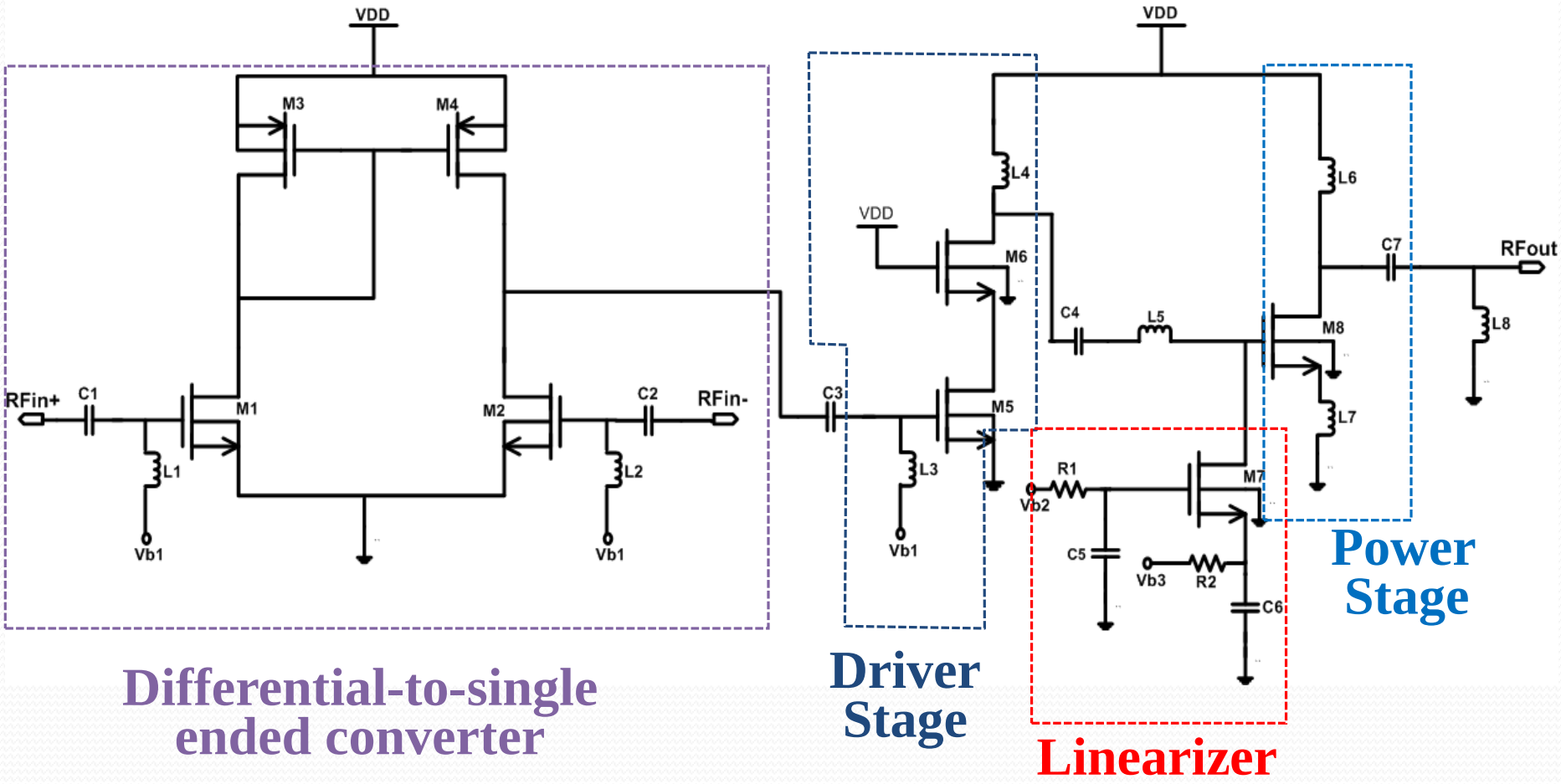
Power Amplifier

Design Parameters

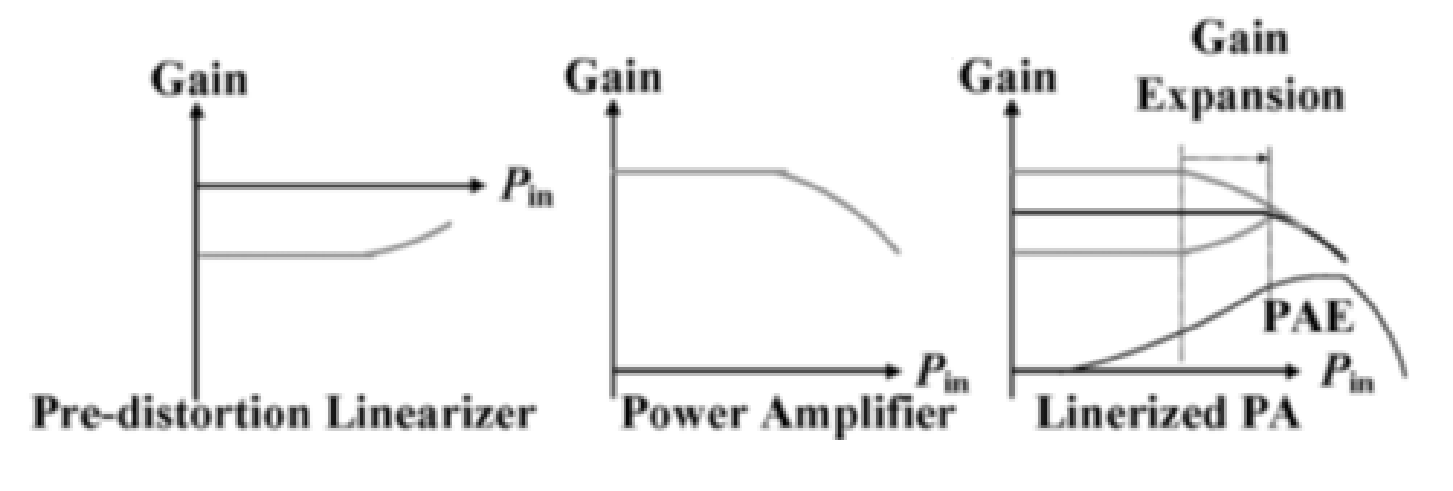
- **Output Power**
- **Gain**
- **Power added efficiency (PAE)**
- **Power consumption**
- **Linearity**

Power Amplifier

- Differential-to-single ended converter as the first stage, a driver stage and a power stage.

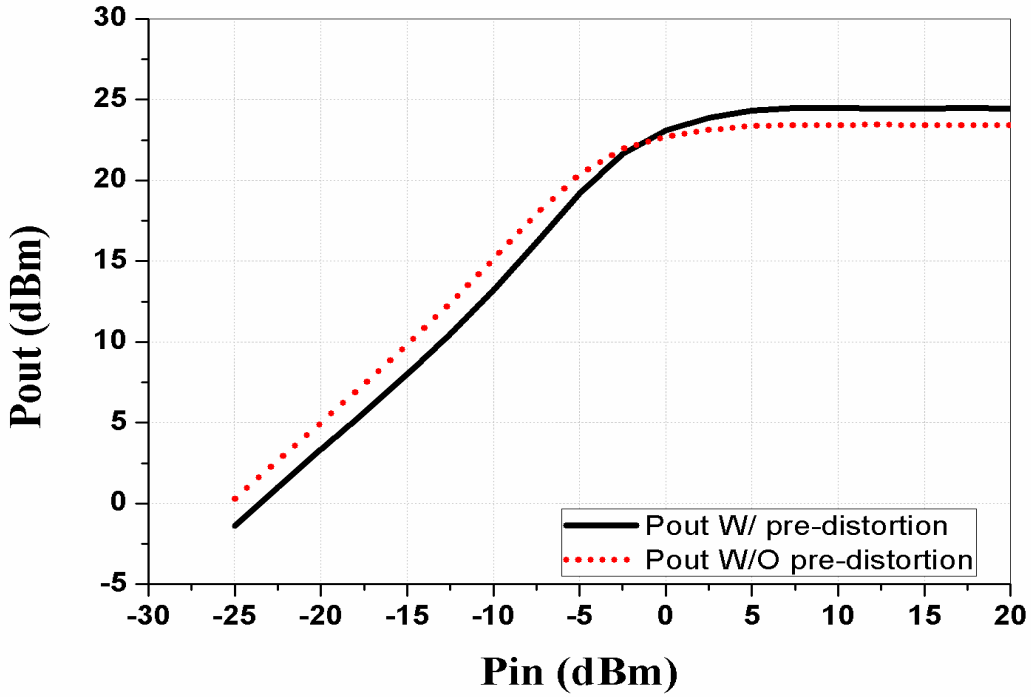


Power Amplifier



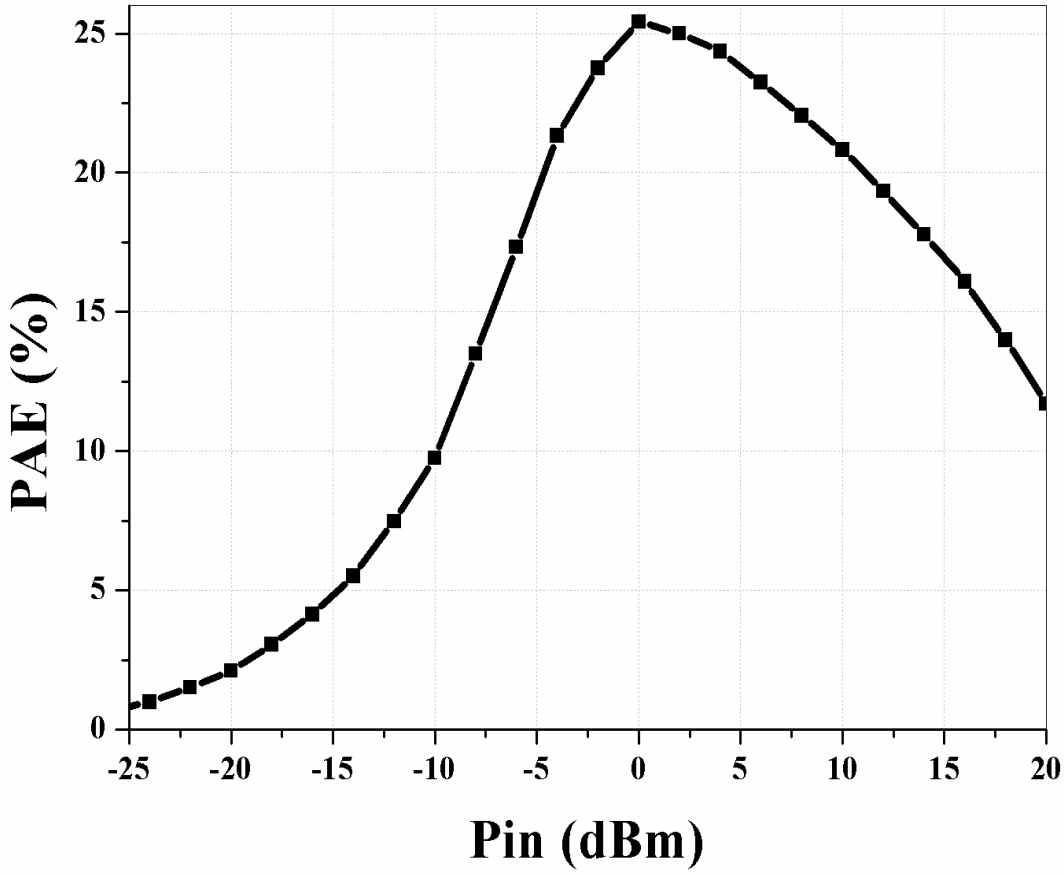
Output Power

- The proposed power amplifier achieves saturated output power of 24.6dBm.
- After linearization, the OP1dBm is improved from 21.3dBm to 22.7dBm at 1.8GHz.



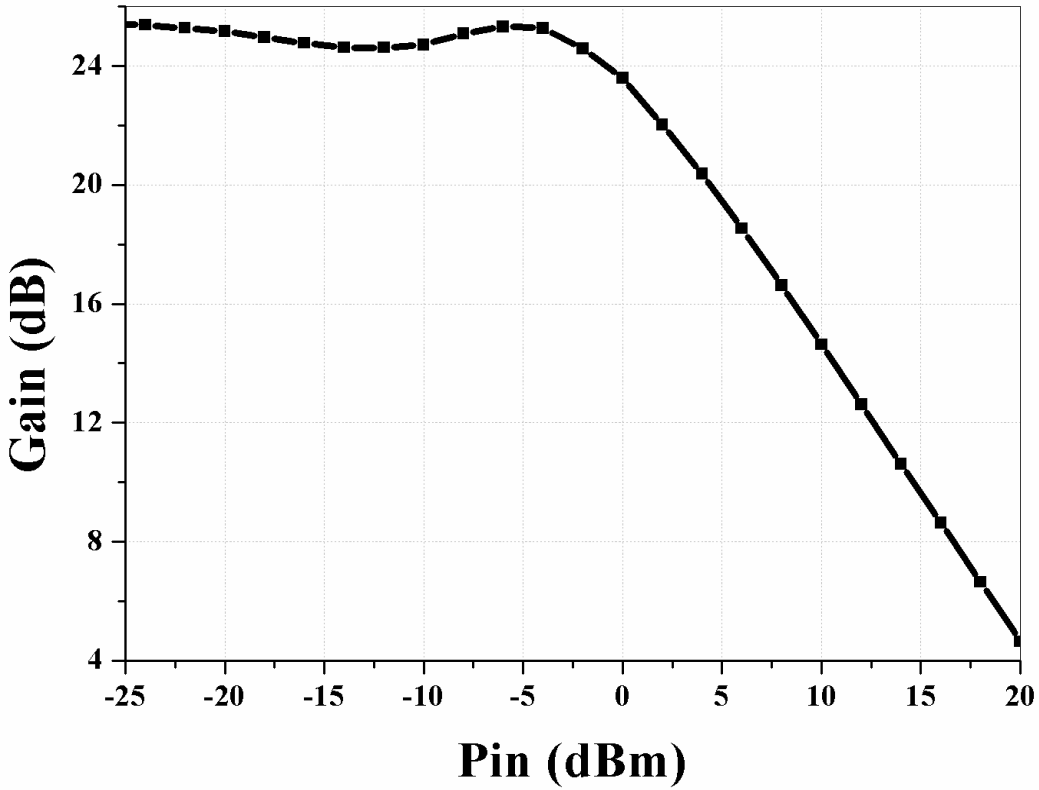
Power added efficiency

- The maximum PAE is 25.5% at input power 0dBm.



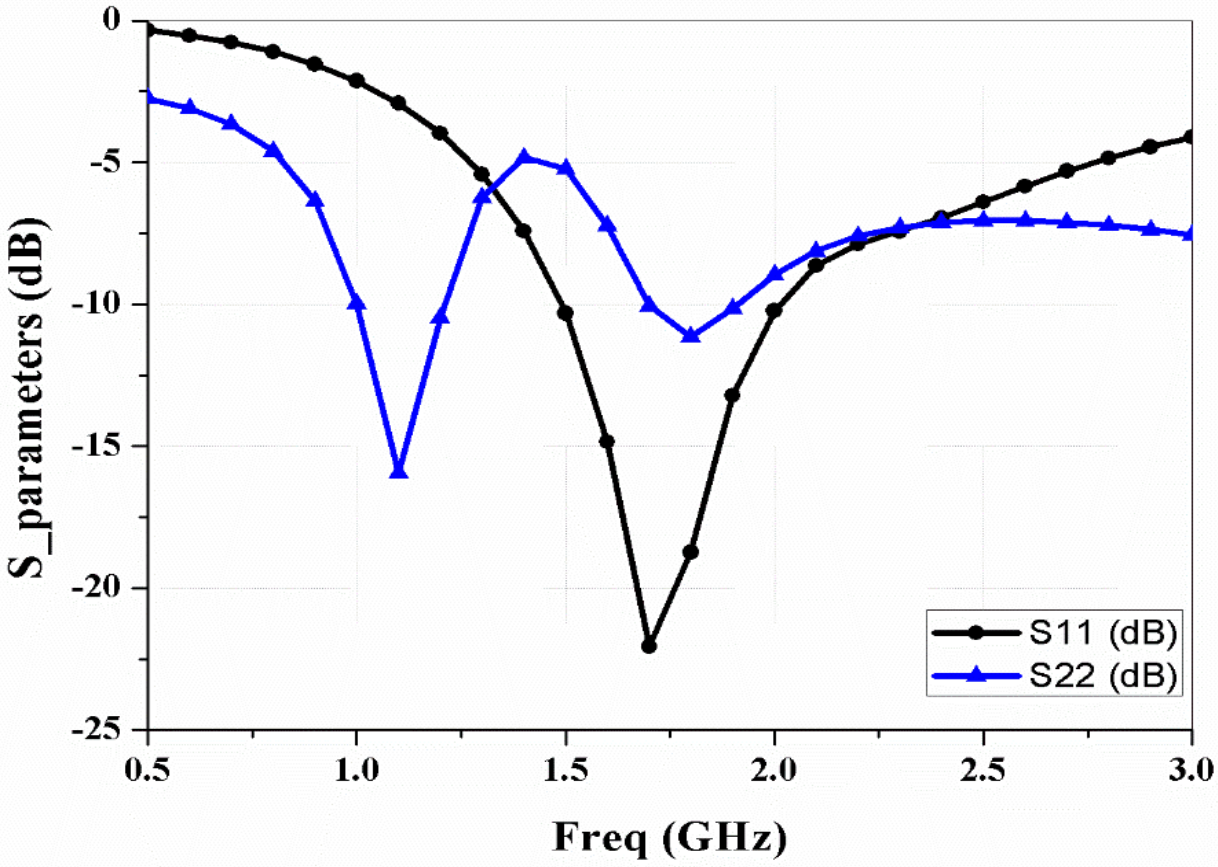
Gain

- The proposed PA achieves a maximum gain of 25.5 dB.
- An output P 1dBm gain compression point of 22.7 dBm.
- The power consumption is 135 mw.



S-parameters

- The input return loss (S11) is less than -18 dB and the output return loss (S22) is less than -13 dB.



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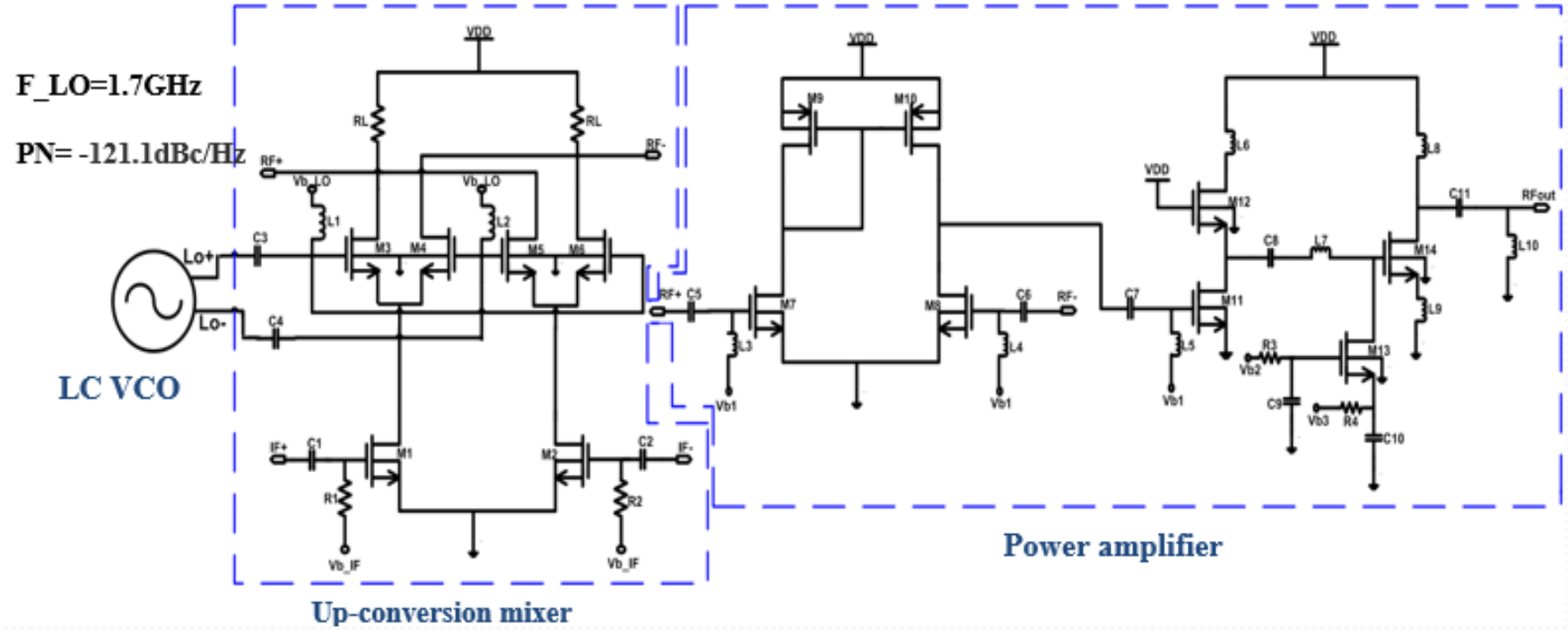
LTE Transmitter

Design Parameters

- **Output Power**
- **Gain**
- **Power consumption**
- **Linearity**

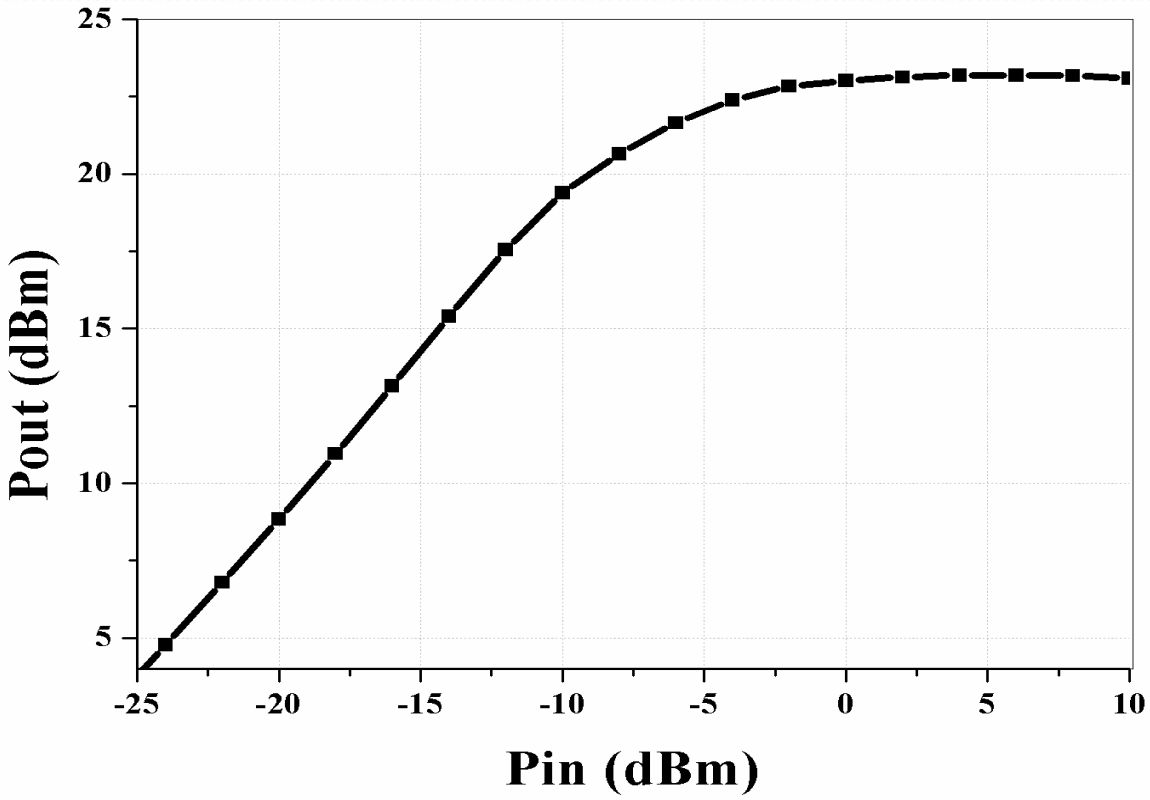
LTE Transmitter RF Front-End

- The proposed CMOS LTE Transmitter Front-End is designed using UMC 130nm CMOS technology at 1.8GHz.



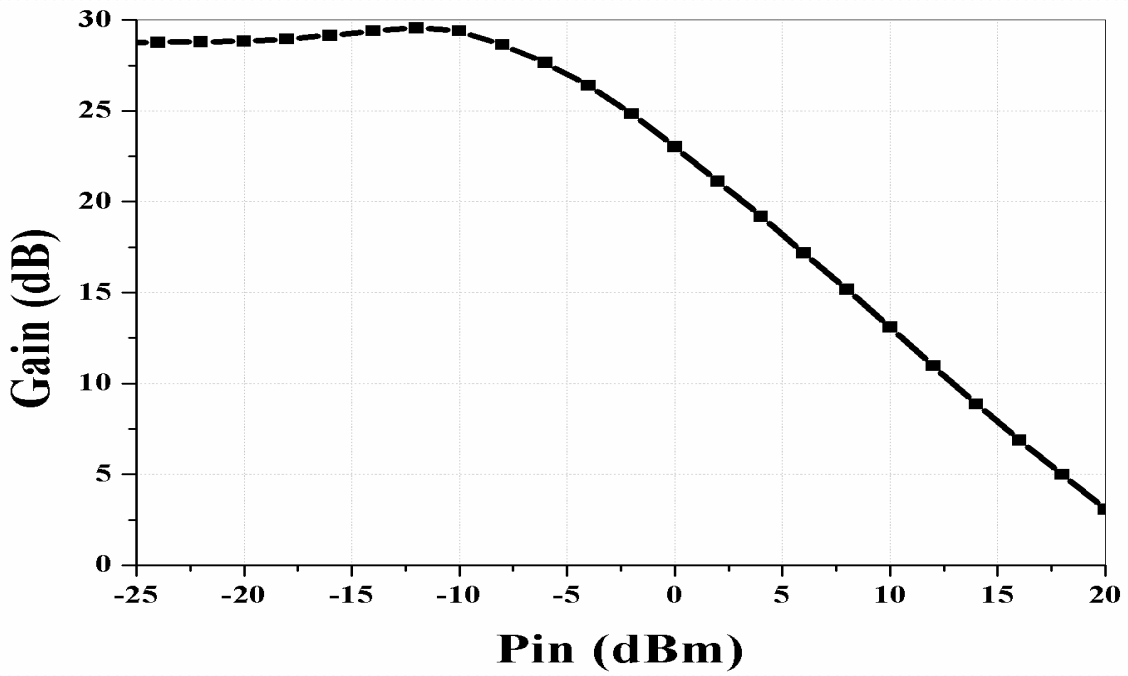
Output power

- A saturated output power of 23.1dBm has been achieved.



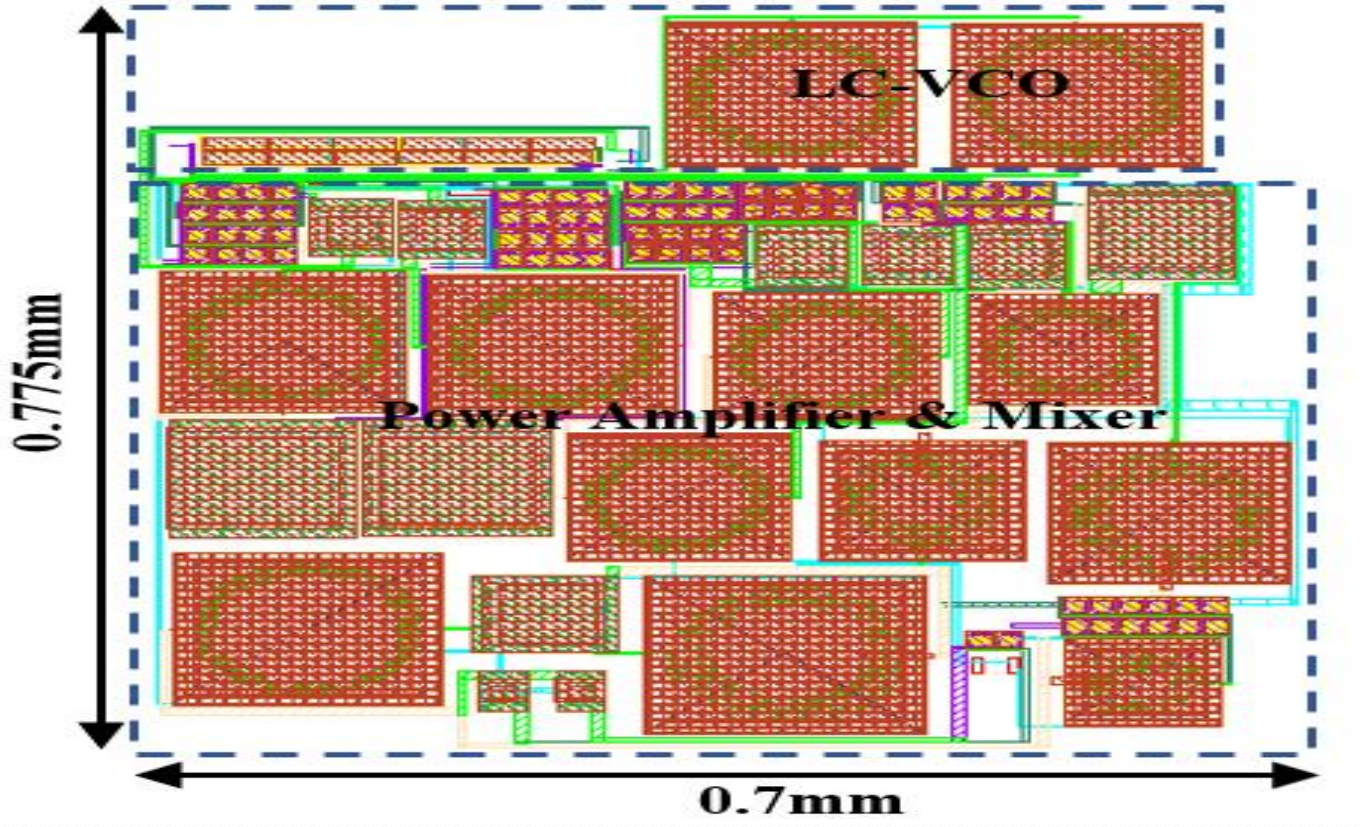
Gain

- A maximum power gain of 29.6 dB.
- An output P1dB gain compression point of 21.5dBm
- Input P1dB gain compression point of -6.2dBm.
- The power consumption is 172.5mW.



Layout view of the implemented transmitter.

- The layout of the complete transmitter circuit, with area of 0.775mm×0.7mm.



The transmitter performance summary

Design	This work
CMOS Technology (nm)	130
Frequency (GHz)	1.8
Gain (dB)	29.6
Output Power (dBm)	23.1
Output power at P1dB (dBm)	21.5
Input power at P1dB (dBm)	-6.2
Voltage Supply (V)	3.3
Power dissipation (mW)	172.5
Area (mm^2)	0.775*0.7

Mixer performance summary and comparison

Parameter	[20]	[21]	[22]	This Work
CMOS Technology (nm)	180	180	130	130
RF Frequency (GHz)	1.8	1.8	1.8 - 2.6	1.8
IF Frequency (MHz)	100	100	N/A	100
Conversion gain (dB)	5	8.1	>1.1	10
Supply voltage (V)	1.2	1.2	1.2	3.3
Power consumption (mW)	9.45	14.28	12	47

PA Performance Summary and Comparison

Parameter	[26]	[27]	[28]		This work
CMOS Technology (nm)	180	180	180		130
Frequency (GHz)	2.6	1.8	1.8	2.6	1.8
Output power (dBm)	N/A	N/A	21.6	18.2	24.6
Power gain (dB)	9.6	28.3	24.6	19.2	25.5
PAE (%)	39.5	32	35.3	31.2	25.5
Output power at P1dB (dBm)	19.5	23.2	N/A	N/A	22.7
Supply voltage (V)	2.8	3.3	3.3		3.3
Power consumption (mW)	26.5	N/A	378		135

Outline

- Objective and the proposed transmitter block diagram.
- LC voltage controlled oscillator.
- Up-conversion mixer.
- Power Amplifier.
- Transmitter Performance.
- **Conclusions and future work.**

Conclusion

- This work presents LTE front-end transmitter for operating frequency from 1.8 GHz has been designed using 0.13μm CMOS technology.

- The proposed transmitter realizes a saturated output power of 23.1dBm, 29.6 dB of power gain, output 1-dB compression point of 21.5dBm, and the power consumption is 172.5mW.

Future Work

- Implement the RF receiver for LTE which include low noise amplifier (LNA), demodulator, and voltage controlled-oscillator (VCO).
- Implement a complete LTE RF transceiver including RF transmitter and RF receiver.
- Fabrication and measurement the LTE power amplifier, mixer, and VCO.

Thank you